ISOCHEMICAL CHARACTERISTICS OF THE CLAY-SULFATE TRANSITION IN GALE CRATER, MARS: APXS RESULTS FROM MONT MERCOU TO THE MARKER BAND VALLEY. J.A. Berger[1*], R. Gellert[2], M.A. McCraig[2], C.D. O'Connell-Cooper[3], J.G. Spray[3], L.M. Thompson[3], S.J. VanBommel[4], A.S. Yen[5], E.B. Rampe[6], J.V. Clark[7]. [1]Jacobs JETSII Contract at NASA JSC; [2]University of Guelph; [3]University of New Brunswick; [4]Washington University in St. Louis; [5]JPL-Caltech [6]NASA JSC; [7]GeoControls Jacobs JETSII Contract at NASA JSC; [*]jeffrey.a.berger@nasa.gov.

Introduction: During sols 3052-3572 (March 2021 to August 2022), *Curiosity* traversed a region in Gale crater where orbital observations predicted a vertical stratigraphic transition from a phyllosilicate unit to the overlying layered sulfates of Mt. Sharp [1, 2]. This region was informally named the clay-sulfate transition (CST). The Alpha Particle X-ray Spectrometer (APXS) was systematically deployed to sedimentary bedrock and selected diagenetic features to analyze possible chemical changes with increasing elevation (a proxy for increasing stratigraphic position). The occurrence of Ca- and Mg-sulfate was a particular focus. Here, we present results from the APXS investigation of the CST, as well as results from the first targets of the sulfate unit located in Marker Band Valley (MBV).

Clay-Sulfate Transition Results: *Bedrock:* The mean concentration of most of the major and minor elements in the CST bedrock is very similar to the underlying Mt. Sharp units, with deviations of < 5% relative to the Mt. Sharp mean (Fig. 1a). Exceptions include the ~25% enrichment of Ca and S, and the ~25% depletion of Cl. Ca and S enrichments correlate positively with a molar Ca:S of ~1, which is consistent with Ca-sulfate addition to bedrock with nearly the same bulk composition as the underlying Mt. Sharp sedimentary units. There is no detectable evidence of changes in Mg-sulfate in the bulk CST bedrock that cannot be attributed to nodules, compared to the underlying Mt. Sharp units (Fig. 2). Cl does not correlate with any single cation, and it is enriched in the top <1 mm of the surface; we do not speculate further here on its apparent depletion.

Diagenetic features: APXS measurements of larger ~2-4 cm nodules indicate minor Mg-sulfate. The nodules are not pure Mg-sulfate; they appear to be a mix of the bedrock with an addition of ~10-15 wt% Mg-sulfate. Mg-sulfate-bearing nodules are not novel to the CST; they have been found in the Carolyn Shoemaker and Murray formations.

Other diagenetic features in the CST include: (1) Fe-rich features (FeO 26-41 wt%), two of which have high Cl (up to 3.5 wt%) and a molar Fe/Cl ~6 indicative of akaganeite. (2) Very high Na+Cl in three features. (3) Ubiquitous cross-cutting white Ca-sulfate veins as found throughout the Mt. Sharp group.

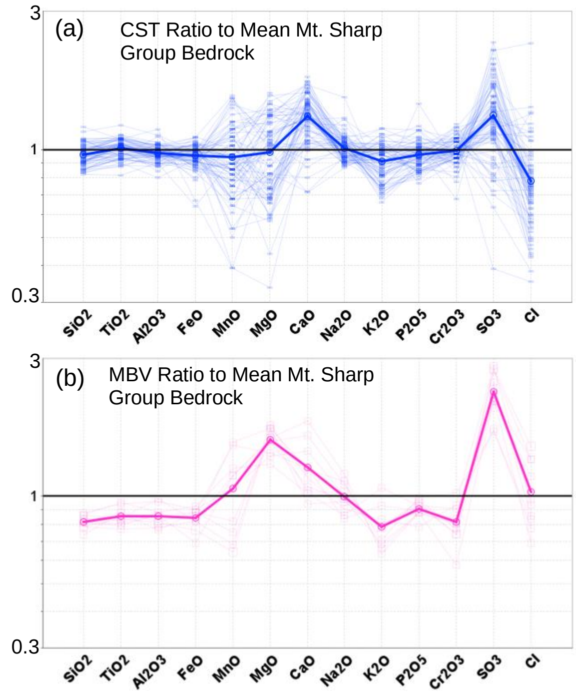

Figure 1: *APXS results for (a) clay-sulfate transition (CST; n = 101) bedrock below the Marker Band Valley (MBV) and (b) 10 targets in the MBV (i.e., sulfate unit). Data are normalized by the mean Mt. Sharp group bedrock above Pahrump Hills. Diagenetic features, NaCl-rich targets, and sandstone lenses are omitted. Mean values are denoted by the bold lines, and all data are fine lines.*

Marker Band Valley Results: The MBV bedrock has a relatively sharp compositional contact with the CST spanning ~5 m elevation change (Figs. 1, 3). Mean MgO increases from 5 ± 1 wt% in brushed and drilled CST targets to 9 ± 1 wt% in MBV targets, including the drilled Canaima. Higher SO_3 correlates with the MgO, increasing from 9 ± 3 wt% to 17 ± 2 wt% in MBV (Fig. 2). Element ratios indicate that the MBV bedrock has roughly the same composition as the underlying CST with Mg-sulfate added (Figs. 1b, 2b). Assuming the mean undiluted MgO and Ca-sulfate of the CST, the added Mg-sulfate in Canaima detected by the APXS is 15 ± 2 wt%. Note that elevated Mg-sulfate has not been found above the Canaima drill site as of sol 3689 [3]. Four targets were discovered in the MBV with

remarkably high Na_2O and Cl (up to 9.4 and 13.5 wt%, respectively). The Na+Cl is interpreted to be halite, although oxychlorine cannot be ruled out.

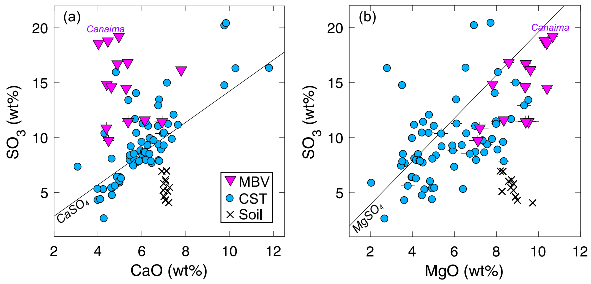

Figure 2: *SO_3 versus (a) CaO and (b) MgO in the CST and MBV. Lines denote pure $CaSO_4$ and $MgSO_4$.*

Implications of an Isochemical Clay-Sulfate Transition: The laminated mudstone and cross-stratified sandstone of the CST and Mt. Sharp bedrock record evidence of paleoenvironmental change, interpreted to be an overall transition from lacustrine to drier aeolian environments [4]. The sedimentary textures and structures indicating this change are broadly consistent with CheMin XRD data showing a decrease in phyllosilicate abundance upsection [5]. Our interpretation of the APXS results is that the bulk chemical composition of the CST is effectively the same as the underlying bedrock of the Carolyn Shoemaker formation, but with ~25% higher Ca-sulfate on average (Fig. 3). Indeed, the CST bedrock has nearly the same composition as the entire Mt. Sharp group (Fig. 1a). The appearance of Mg-sulfate at ~15 wt% (crystalline and/or amorphous) in the bedrock occurs above a relatively sharp contact in the MBV, and then disappears in the marker band and overlying bedrock [3, 5]. Thus, the Mt. Sharp group contains a sequence of mudstone and sandstone interpreted to record changing paleo-environments in lacustrine/aeolian settings, but the bulk major and minor elements do not vary significantly. Is this due to a singular, unvarying provenance? If so, it isn't unaltered soil-like basalt; the average composition of the Mt. Sharp group bedrock deviates from the presumed basaltic provenance with a uniform depletion in Ca, Mg, and Mn and enrichment in Si, K, P, Zn, and Ge [6], indicating significant open-system alteration of a basaltic precursor. Was this precursor altered under singular geochemical conditions? Models of changing paleo-environments must account for these isochemical characteristics and the sharp increase in Mg-sulfate and NaCl in the MBV. For example, does a model explain how a phyllosilicate-bearing, laminated mudstone has nearly the same bulk major and minor element composition as a cross-stratified sandstone?

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References: [1] Fraeman et al. (2016) JGR *Planets*, *121*(9), 1713–1736. [2] Milliken et al. (2010). *GRL*, *37*, 6. [3] Thompson et al., (*this conference*). [4] Gupta et al., (*this conference*). [5] Rampe et al., (*this conference*). [6] Gellert et al., (*this conference*).

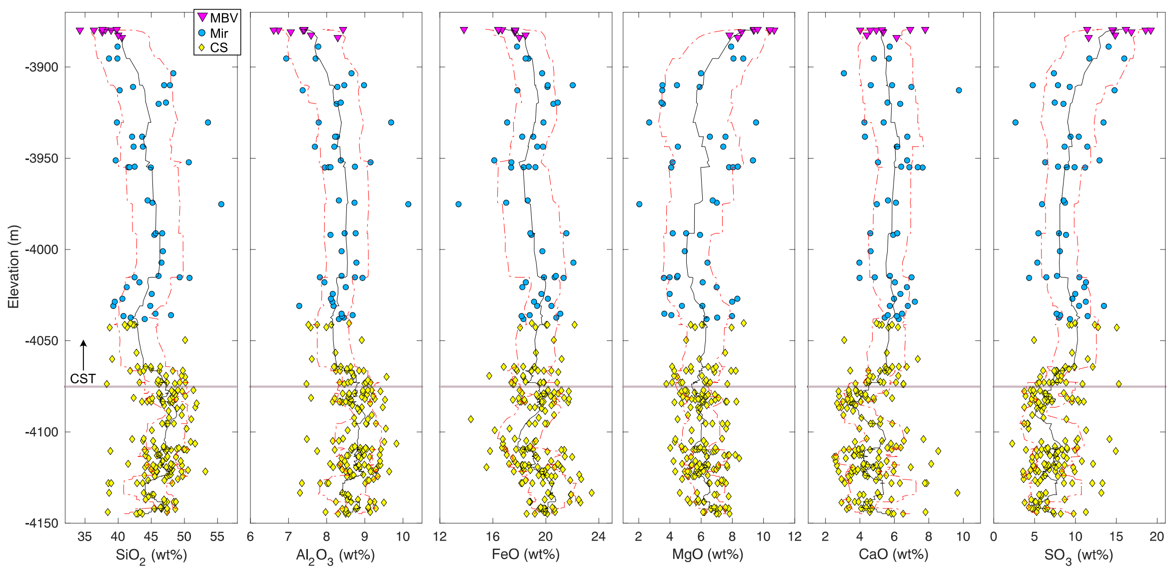

Figure 3: *Chemostratigraphic profiles of major elements in the Clay-Sulfate Transition (CST), which begins at -4080 m, with 70 m of underlying strata for comparison. The Carolyn Shoemaker fm. (CS), Mirador fm. (Mir), and Marker Band Valley (MBV) are indicated. Diagenetic features and duplicate measurements are omitted. The 15-point moving mean (solid line) and ± 1σ (dotted line) are shown.*